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Geology of the Launceston District, Tasmania

By

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Introduction

Definition of Area

This report presents the regional geology of the area of approximately 112 square miles lying between latitudes 41° 22½′ and 41° 30′ South, and longitudes 147° 0′ and 147° 15′ East. The City of Launceston is centrally placed within this area.

Geological Map

A geological map (Plate III) accompanies this report. It has been compiled from geological boundaries marked on aerial photographs by stereoscopic interpretation, and from identification in the field. The planimetric compilation from the photographs is very approximate and is therefore intended only as an interim map pending proper ground control and preparation of rigorous control sheets.

A series of perspective diagrams (Figures 1-4) has been prepared to depict in a generalised way the geomorphology and structural growth of the Launceston district during the Tertiary period.

Previous Literature

Beginning with Strzelecki over a century ago, there have been a number of accounts relating to the geology of the area. These range from the pioneer contributions of R. M. Johnston to reports, many of them unpublished, on various special subjects, and are listed with the references.

Acknowledgements

Most of the field work was carried out in connection with investigations on behalf of the Hydro-Electric Commission of Tasmania, and the account herein presented is published through the courtesy of the Commission.

I am also indebted to Mr. H. J. Read for the photographs of the Tertiary fossils (Plates IV and V), and to the Director of the Tasmanian Government Tourist Bureau for permission to use the photograph of Launceston (Plate VI)

Stratigraphy and Geological History

Permian

Jurassic dolerite is the dominant bedrock in the Launceston district and formations older than the dolerite are known only from scattered fragmentary remnants. The earliest rocks shown in the area are mudstones of Permian age.

There are no records of fossils in these mudstones nor have any been found during the present work, but the lithological characters are sufficiently distinctive to permit their identification with certainty.

Permian sediments have been found in three localities within the area of the map, and a fourth occurrence a little further north is also worthy of mention:

(1) An inlier of Permian mudstones occurs in the hills on the north side of the Rosevale-Launceston Road about three miles south-east of Bridgenorth. The area, which is about one square mile in extent, occurs in the northern half of photograpn No. 4771 of Run 4 of the Launceston quadrangle. Structurally the Permian is an inlier of the floor of the great dolerite sill which dominates this region; it outcrops for a short distance where the dolerite has been locally stripped off on the upthrown side of the Breadalbane fault.

The Permian rocks consist largely of rhythmically bedded mudstones, but a sandier phase which is more resistant to erosion tends to form shoulders, and caps some of the hills. This phase is reminiscent of the Risdon sandstone of the Hobart district and possibly belongs to that horizon. Below it the mudstones are pebbly, with occasional erratics up to eight inches long of schist and other basement rocks. This phase is similar to the Lindisfarne formation which underlies the Risdon sandstone in the Hobart district.

(2) Permian mudstones are exposed in the road cuttings for 200 yards on the south side of the bridge over the North Esk River at Corra Lynn. They also occur for a couple of hundred yards up the hillside to the south-east, but here they are for the most part covered by a superficial veneer of Miocene mudstones. A further small patch is exposed in a gully about 400 yards in an easterly direction from the Corra Lynn Bridge. All these outcrops are barren mudstones rhythmically bedded and well jointed. They closely resemble the Ferntree mudstones of the Hobart district and probably belong to this formation. Structurally they are remnants of the roof of the dolerite sill, most of the roof having been stripped off. This structural relationship confirms the stratigraphic correlation, because if the floor of the sill in the inlier towards Bridgenorth is correctly identified as Lindisfarne mudstones and Risdon sandstones, the roof rocks would be Ferntree mudstones. The terms Lindisfarne mudstones and Ferntree mudstones are used in the sense defined by Lewis (1946, p. 34), while the term Risdon sandstone is used in the sense defined by Carey and Henderson (1945).

(3) Permian mudstones are exposed again in the road cuttings on the hill running down from St. Leonards to the North Esk River. These mudstones occupy a similar stratigraphical and structural position to those at Corra Lynn, and like the latter, they have been preserved from denudation because they have been let down into the dolerite by a small fault.

(4) Coal measures of Permian age are present at Dilston on the east side of the Tamar four miles north of the boundary of the map. An abandoned coal mine, now used as a water well, occurs on the flat about four hundred yards behind the Dilston Post Office. All the hill outcrops surrounding the flat are dolerite and no outcrops of Permian sediments could be seen on the flat. However, two mounds, residuals of the half-century old spoil dumps of the mine, consist of cherts and fire-clay respectively. From their lithology there seems no doubt that these rocks are Permian. A fault line runs along the boundary of the dolerite along the north-east side of the flat.

Lithologically these Permian sediments more closely resemble the Ferntree mudstones than any other formation. The regional structure suggests that they are, like the outcrops of Corra Lynn, remnant inliers of the roof of the dolerite sill. The coal measures are therefore probably to be correlated with the upper

Permian coal measures—the Cygnet stage of Lewis (Loc. cit., p. 34). However, in view of the meagreness of the local evidence this correlation must be regarded as speculative.

The highly cherty character of the Dilston rock might at first sight suggest that these cherts belong to a different part of the Permian sequence from the Ferntree mudstones. But the cherty aspect is not stratigraphically significant since it is due mainly to contact silicification by the dolerite. Thus Johnston (1874, p. 55) has described a transition from the normal white mudstones of the Ferntree type into hard cherts as the dolerite contact is approached. This exposure occurs on the railway line at Hunter's Mill, Perth, a few miles south of the area covered by the geological map. Johnston reports that the mudstone there is 'of considerable thickness. It presents the appearance of a baked pipe clay, being exteriorly of a whitish colour, and breaking readily into small hardened cubes. When most distant from the underlying basalt (1), it is soft and friable and internally white; it becomes more hardened as it approaches the igneous rock, until finally at point of contact it is metamorphosed into a dark close-grained crystalline chert, which no longer splits into cubes, but has a smooth conchoidal fracture'. This flinty material appears to have been used by the aborigines as a source of stone for their chipped implements.

With the exception of the Dilston coal, all the Permian rocks in the area are considered to be marine. This is based on analogy with type sections of the Permian. No direct evidence has been found in this area.

Triassic and Jurassic

No Mesozoic sediments are known within the area mapped. Johnston (1888, p. 178) has reported the presence of Mesozoic sandstones in the Hadspen district just south of the area. These extend along the strike to Longford. Strong faults trending north-west along the South Esk Valley between Hadspen and Longford drop down the bedrock to the south-west and account for the presence of Mesozoic strata in that area. Similar Mesozoic rocks undoubtedly extended throughout the Launceston area originally but prolonged denudation of the upper Mesozoic and lower Tertiary completely stripped them, exposing the underlying dolerite sill which is here intrusive into the Permian.

Jurassic Dolerite

The sedimentary cycle of the Permian and Triassic was terminated during the Jurassic period by widespread injection of dolerite. In the Launceston district the dolerite spread laterally as a great sill, not less than 500 feet thick and probably nearer 1000 feet thick, invading the upper Permian sediments on a horizon a little above the Risdon sandstone. It is fairly common to find thick dolerite sills intruding the Permian sediments on this general horizon. The thick sill overlooking Waddamana Power Station is on this horizon, as also is the dolerite mass about Lindisfarne near Hobart.

Subsequent erosion and tectonic events have widely exposed the dolerite so that it is now the dominant bedrock of the district.

Late Mesozoic Peneplanation

Following the dolerite invasion the landscape had considerable relief, probably in the form of a rugged plateau standing a couple of thousand feet or more above sea level.

(1) For 'basalt' read 'dolerite'—(S.W.C.)

During the next ninety million years or so nothing spectacular occurred, and this plateau was continuously attacked by weathering and denudation. As a result the roof rocks of the dolerite sill and much of the dolerite itself were stripped off extensive areas, leading to the development of a widespread peneplain (Fig. 1). The evidence everywhere points to the conclusion that this peneplain reached a high degree of perfection. No protuberances suggestive of old monadnocks on this peneplain have been recognised. However, it is highly probable that such erosional residuals did remain marking the roots of earlier orogens, but if so they have not so far been recognised.

As this peneplanation became more and more complete, deep chemical weathering increased in importance and physical denudation progressively declined. By this time the climate had changed to one of winter rains and summer drought favourable to the formation of a surface crust of laterite. Since dolerite is rich in alumina and iron and low in free silica, those areas where the surface was occupied by dolerite acquired a weathering crust of ferruginous bauxite, consisting of a surface skin three to five feet thick of hard highly ferruginous bauxite and a paler more earthy underzone ten to twenty feet in thickness of less ferruginous bauxite. At this stage bauxite covered very extensive areas throughout the Launceston region, and although subsequent events have covered much of it and stripped and dissipated a good deal more, there are still quite a number of small outcrops of it scattered widely through the district, as shown on the geological map. All these outcrops are remnants of the old peneplain surface.

Lower Miocene Faulting

The lower Tertiary peneplain with its laterite and bauxite crust was broken up during the early Miocene by violent faulting. The Great Western Tiers and the Ben Lomond Highlands were uplifted along a series of step-faults with a north-westerly trend, and the Midlands area between them was left as a low lying trough. In the middle of this trough a horst, which extended from Hummocky Hills through Breadalbane and along the south-west bank of the present Tamar towards Beaconsfield, was uplifted to heights of 600 feet upwards to 1500 feet to form a lesser range between the more lofty Tiers on the south-west and the high Ben Lomond horst to the north-east. This faulting was most complex. Each uplift was the summation of a bundle of parallel faults, rather than a single fracture. A generalised picture of the Launceston district immediately after this epoch of faulting is shown in the second block diagram (Fig. 2).

The faults all seem to be normal with steeply dipping fault planes showing little evidence of strike shift movement. This conclusion is based on the attitudes of the fault planes where they actually outcrop or are met in tunnels, the relation of outcrop to contour, the dip of the associated joints, the direction of the slickensides, and analogy with other faults belonging to this same epoch in other parts of Tasmania.

The blocks between the faults were tilted and in some cases warped and buckled. Most of the blocks between the Ben Lomond horst and the Tamar trough were tilted to the south-west. The floor of the Tamar trough was warped into a broad synclinal depression. The monoclinal warp forming the north-east flank of this trough appears to continue in a south-easterly direction for fifty miles, crossing the Elizabeth River east of Campbell Town, then veering southerly and south-westerly to Woodbury. These features can be seen on the block diagram. Within the area of the geological map, a synclinal depression occurs in the block between the Breadalbane and Glen Dhu faults.

The broad distribution of the emergent and lagging zones during the uplift suggests that although the surface development of the Oligocene peneplain may have approached perfection, the sub-crustal razing of the orogenic roots had not been so complete. Within these roots lay the seeds of isostatic regeneration—the Ben Lomond horst coincides with the Middle Palaeozoic orogenic belt; the Hummocky horst axis coincides with the very old core of Pre-Cambrian rocks which runs out to sea at Asbestos Point; while the Western Tiers uplift (though here the information is more vague) may coincide with a Lower Palaeozoic orogen.

Although the incidence of the uplift seems to be related to isostatic readjustments of old orogenic roots, the north-westerly trend of the fractures is a novel feature dating only from the Miocene. It is nevertheless quite general throughout Tasmania. The origin and significance of this trend, transgressing as it does all the older grains of the island, has not yet been clarified.

The system of north-west trending faults and associated minor shear zones is a prominent feature of the geological map of the Launceston district, and has had a decisive controlling influence in the recent development of the topography. The northern boundary of the dolerite along the West Tamar Road rises as a linear ramp from the flood plain of the Tamar. Fringing the hill there are occasional low outcrops of Tertiary sediments. This boundary has been interpreted as a fault throwing down to the north-east, and has been called the Trevallyn fault. The dolerite cuts out at the southern outskirts of the City of Launceston and passes beneath the Tertiary sediments so that the continuity of the supposed fault is temporarily lost. However, the dolerite reappears through a thinning mantle of Tertiary sediments at Carr Villa and from there towards Relbia the dolerite outcrops strongly again. Moreover, the later Tertiary sediments which accumulated against the fault scarp until they ultimately swamped it, are still present on the down-thrown side so that the throw of the fault cannot be assessed.

Some evidence suggests that the supposed Trevallyn fault has no real existence and that the sudden rise of the dolerite along this line is merely the dip-slope of a tilted block of the old Tertiary peneplain, the faulting being confined to the Glen Dhu line further to the south-west. I have been unable to decide this point to my satisfaction on the evidence so far available.

Parallel to the questioned Trevallyn fault and a little further back is the Glen Dhu fault which runs to the south-west of Carr Villa and forms the scarp at the wireless station and along Hillside Crescent on the outskirts of the town. It then continues on through the First Basin, which owes its presence in part to this fault, and carries on to the north-west, giving rise to a valley and series of depressions parallel to the West Tamar Road and a mile or so behind it. The Glen Dhu fault and the joints associated with it outcrop at the First Basin on the south east side of the river between the suspension bridge and the parking area.

A branch of the Glen Dhu fault runs down a narrow graben round about the First Basin and extends as far as the Trevallyn school. In this graben the remains of the old peneplain surface are still preserved in the form of several outcrops of bauxite which may be seen within the town itself round about Hillside Crescent, Connaught Crescent and Neika Avenue, at the parking area near the First Basin, and again at the other parking area above the Cliff Grounds park across the river. The Glen Dhu fault, like the Trevallyn fault, throws down to the north-east but its throw is probably not more than 200 feet. This graben continues to the north-west across the Bridgenorth road where it is occupied by a considerable area of later Miocene sediments. The floor of the graben here probably dips to the south-west, because wherever bauxite has been found (indicating the old peneplain surface) it is on the north-east side of the graben, with Miocene sediments covering it on the south-west side.

Further back again and parallel to these faults is the Breadalbane fault, the scarp of which may be picked up near Western Junction and followed from there north-westwards for 16 miles. This fault has a throw of 700 feet with the down-thrown side again on the north-east. Standing on top of the eminence known as Cocked Hat Hill about a mile north of the junction of the Evandale road and the Midlands Highway at Breadalbane, one can see to the north-west the scarp of this fault with the flat platform of the country between the Breadalbane and Glen Dhu faults standing at a level some 300 feet below the country to the south-west. Driving along the road from Rosevale towards Launceston, this scarp makes a prominent feature; after travelling for some miles along the top of the up-thrown block one suddenly comes out on to the edge of the scarp and has an open view ahead of the broad Tamar Valley. A rapid descent is then made and the road proceeds along the lower platform for some miles before coming out on the edge of the next scarp with another broad view of the Tamar Valley.

Further south-west again is the Hadspen fault which throws down this time to the south-west. The block between the Breadalbane fault and the Hadspen fault is a horst; it is the most elevated portion of this step-faulted région and the faults throw down on either side of it. This structure shows up clearly on the block diagram (Fig. 3).

South-west of Hadspen and running through from there south-eastwards to the south-west flank of the Hummocky Hills and extending north-westwards towards Frankford is another powerful fault of this series. This I have called the Longford fault because its concealed outcrop must pass close to the township of Longford. At Norwich, about a mile from Longford, Mesozoic coal measures are worked near the surface, while a mile or so to the south-west bores have been sunk nearly 900 feet entirely in Miocene sediments. Between the coal measures and this bore lies the concealed fault scarp of the Longford fault whose throw must be of the order of at least 1000 feet to the south-west.

Thus the hills between the Longford fault and the Tamar Valley are built like a stile, the blocks rising several hundred feet at a time in giant steps with treads a mile or so wide. These steps reach their crests between the Hadspen fault and the Breadalbane fault and then lead down again to the Tamar Valley. Owing to the fact that the subsequent filling material has been largely removed from the Tamar Valley but is still present on the other side of the horst extending over the Meander plains to the foothills of the Western Tiers, the symmetry of this structure is partially obscured. On the other side of the Tamar, the dolerite rises in a series of ramps and steps between Mowbray and Mounts Arthur and Barrow. Here the elevation, at least near Launceston, is brought about mostly in the ramps, while the faults let down to the north-east in opposition to the ramps. Several of these faults are shown on the map, but in no case is their throw considered great. One of them crosses the North Esk in the vicinity of the Corra Lynn bridge and its joints have controlled the form of the river at this point. It is a normal fault with a throw of about 50 feet, bringing down a segment of Permian mudstones on one side against the underlying dolerite on the other side. What is probably the same fault crosses the road from St. Leonards township to St. Leonards railway station two and a quarter miles to the north-west. Here the throw is about the same as at Corra Lynn with an inlier of Permian mudstones preserved from erosion on the down-thrown (north-east) side of the fault.

In addition to these primary faults which all trend in a north-westerly direction, there are two pronounced systems of joints in the dolerite wherever it is exposed. These show up strongly on the aerial photographs and may be seen in every natural or artificial exposure in the dolerite in the district. One set of these joints trends in a north-westerly direction parallel to the major faults, and probably ranges in magnitude from mere joints with little or no differential movement, through small faults with a few feet of movement and up to the size of fairly important faults. Almost at right angles to this system is another trending north-east. Both systems are clearly exposed in the dolerite quarry on the south-east side of Trevallyn Bridge and in several places along the South Esk gorge. They can be clearly seen from the suspension bridge at the First Basin and again across the flume supplying water to the Launceston power house. In the tunnel which carries part of the water to this power house the joints and shear zones intersected belong very largely to the north-west trending group and these were responsible for a good deal of overbreak when the tunnel was being driven. Both sets of joints are prominent in the vicinity of Corra Lynn. In the north-east corner of the map the north-east trending set seems to be dominant.

The joint systems have been the controlling factor in the development of the stream pattern in the district. The various reaches of the South Esk and the North Esk Rivers and their many tributaries are controlled almost entirely by these joint systems. The joints therefore show up very prominently on the aerial photographs and many of the more important shear zones are shown on the map. However, the selection of those to be included in the map is rather arbitrary since the shears and joints range in size from major fractures to closely-spaced joints; no map could show them all because they are developed at intervals of 2 or 3 feet.

Miocene Sedimentation

The great epoch of faulting which broke up the early Tertiary peneplain resulted in a new series of mountains in the Launceston district, 2000 feet and more in height and bounded by steep fault scarps. Still higher mountains resulted in the Ben Lomond area and the Western Tiers. A generalised picture of the country at this stage is shown in the block diagram (Fig. 4). Between these fault blocks there were depressed areas, some of which were areas of internal drainage and so became lakes. This was the condition about Launceston and two great lakes came into being in this region, Lake Cressy and Lake Tamar. Lake Cressy was over 50 miles long and from 10 to 20 miles wide and extended almost from Frankford to Campbell Town, while Lake Tamar on the other side of the Hummocky horst was almost as long but rather narrower. Into these lakes the streams running off the dolerite and uplifted plateau surfaces washed large quantities of sediments, which accumulated rapidly to great thicknesses, over a thousand feet in the deepest places. The level of sediments rose and the lakes expanded in their areas as a result of the erosion and attrition of the banks. In this way, Lake Cressy and Lake Tamar eventually became united into one great lake which Johnston has called the Launceston Tertiary Lake and which we may shorten to Lake Launceston (see Fig. 3). This lake consisted of two great reaches embracing the original Cressy and Tamar lakes, separated by a low ridge and with shallow connections joining them across this rock bar. The ridge was formed by the medial horst which rose a couple of hundred feet above the lake surface, with occasional peaks, such as Hummocky Hills, rising higher.

The sediments of the Launceston series which accumulated in the lake varied a good deal. There were coarse boulder beds consisting largely of boulders of dolerite stripped off the newly-uplifted blocks. One of these conglomerates in the neighbourhood of Corra Lynn has been described by Johnston (1888, p. 271), as a series of brecciated tuffs and agglomerates which abut horizontally against the bordering dolerite. I have re-examined this section and regard the rock as being a fairly normal conglomerate. I consider that the boulders are re-distributed earthquake debris derived largely from smashed-up material, large quantities of which

FIGURE.1.
OLIGOCENE

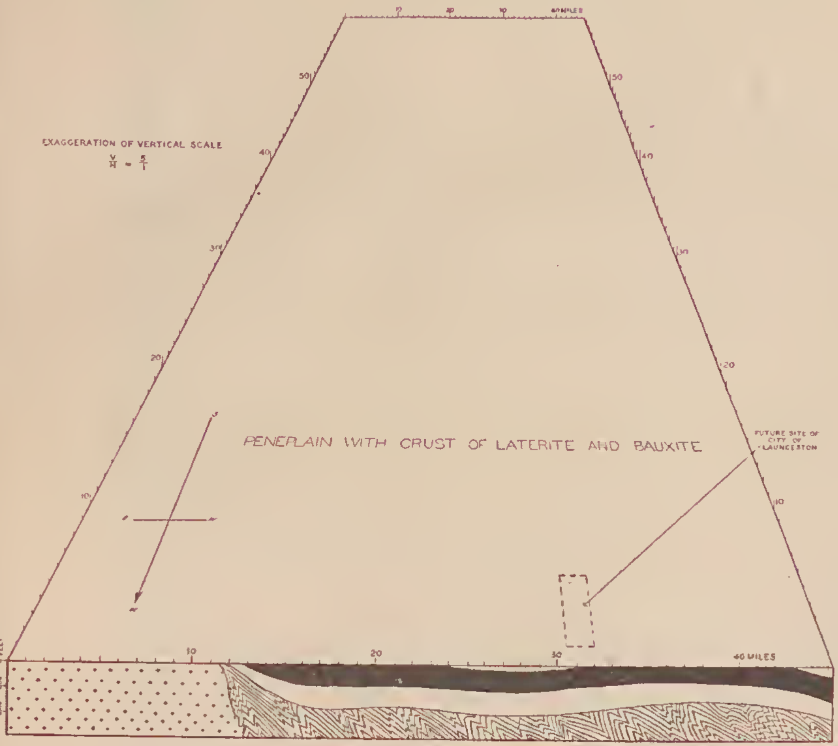


FIGURE.2.
LOWER MIOCENE FAULTING

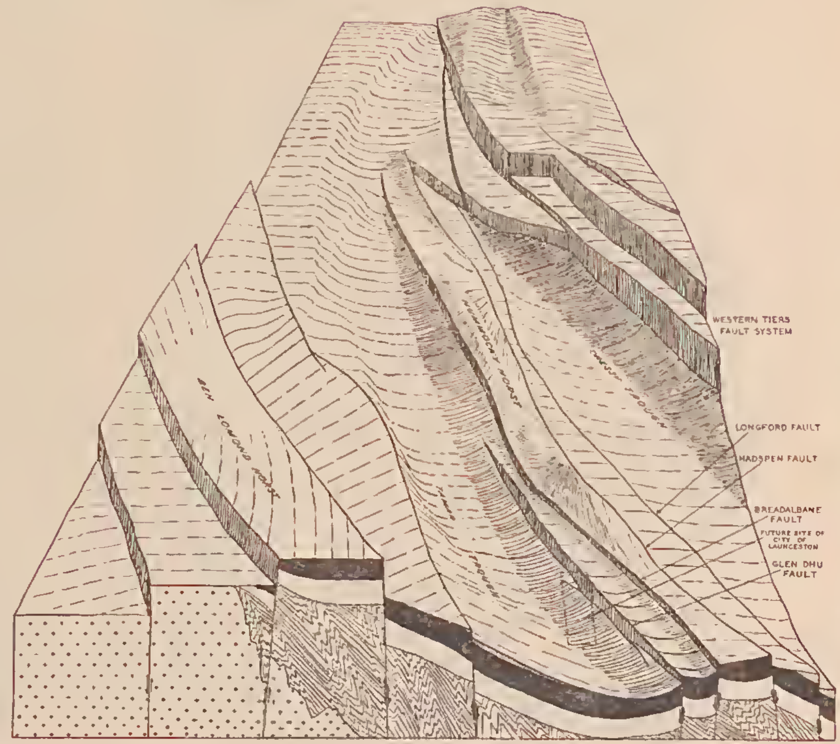


FIG. 1.—The Oligocene peneplain as it was 35 million years ago after some ninety million years of uninterrupted denudation.

FIG. 2.—The same area immediately after the Lower Miocene faulting about 30 million years ago (simplified and generalised).

FIG. 3.—The Miocene lakes showing rapid dissection of the new mountains, filling up the depressions with gravels, sands, and clays to a thickness of over a thousand feet. It was during this epoch that the *Cinnamonum Fagus* flora represented by Plates IV and V flourished.

FIG. 4.—Present day, after diversion of the Upper North Esk River into the South Esk by basalt flows near Evandale and the scouring out of the Miocene sediments from the Tamar Valley.

FIGURE 3.
UPPER MIOCENE

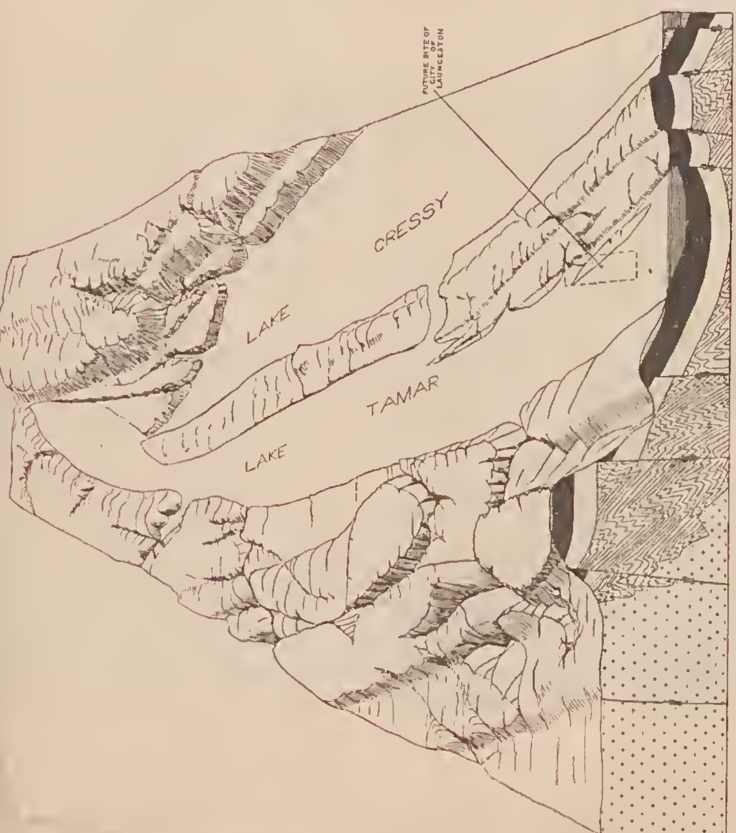
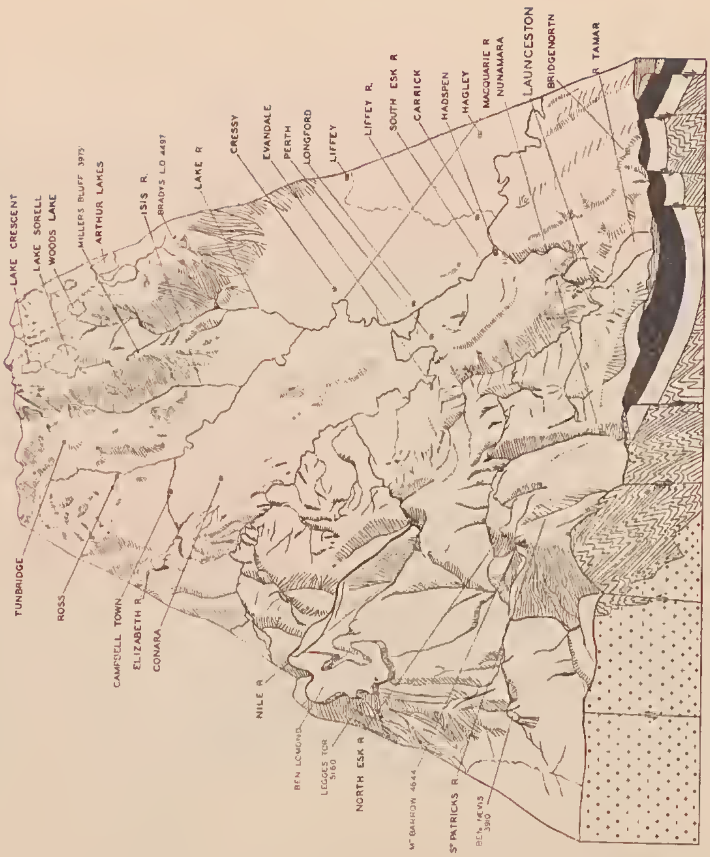
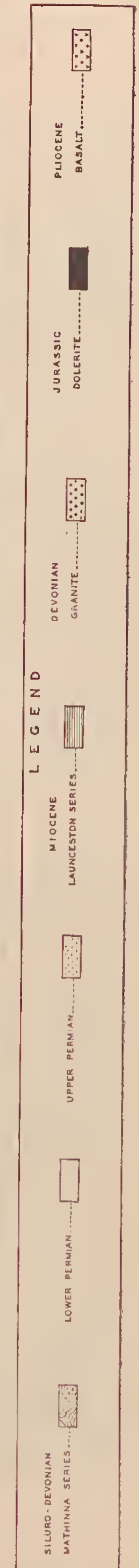


FIGURE 4
PRESENT DAY





occur on the surface following a period of faulting such as ushered in this epoch. I think that the matrix is largely of similar origin though of a finer grade; it is not necessarily tuffaceous. Johnston has described pine and banksia fossil wood which occurs fairly abundantly in this conglomerate. These are all water-worn fragments and blocks and one might get the impression that they were derived in their petrified state from an earlier formation. However, I do not think this is the case, but that they were pieces of logs which were fretted and abraded among the bouldery material with which they were transported. I have seen mudflow-filled valleys after a major earthquake in New Guinea in which boulders, rock fragments, mud and broken logs flow in a semi-fluid mass down the valley with each rain. This environment would produce the sort of end product such as that which Johnston has described from Corra Lynn. It is probably very near the base of the Tertiary section.

Seams of lignite are characteristic of the early part of this lake sequence. Outcrops of these lignites may be examined along the rock platform westwards from the Legana jetty on the north side of Freshwater Point in the Tamar, and they have been encountered elsewhere in bores. Johnston has described in detail (1874, pp. 56-57, and elsewhere) the lignite seam in the railway cutting at Breadalbane (Relbia). The lignite is ' between 3 and 4 feet thick. It is generally very impure and frequently contains the entire, though much compressed, trunks and branches of trees. The woods are evidently a lignified form of those preserved in a carbonate of lime at Corra Lynn '. Scott (1930) has described the lignite occurrence near Muddy Creek, West Tamar, and gives a proximate analysis of a weathered sample:—

Fixed Carbon	15·98
Volatile combustible matter	29·82
Ash	46·70
Sulphur	0·36
Moisture	7·50

At least one lignite horizon seems to be present in every complete section of these Miocene sediments. Even in the arms of the Tertiary lake, as at Tullochgorum, a lignite horizon is present. Lignite occurs in the Miocene lake deposits at Ouse. Again, at King Island a lignite horizon is found following a lower Miocene marine horizon, and in the Miocene of Victoria lignite is very extensively developed. Although it is probable that lignite occurs on more than one horizon, it is likely that there is a restricted number of horizons which represent particular phases in the climatic oscillations of the Miocene. Detailed investigations would probably permit such horizons to be used as marker horizons for correlation purposes. The rest of the Tertiary sequence consists largely of clays, sands and gravels. A clay content is a conspicuous feature of the whole sequence. This seems to have been derived from the stripping and denudation of the under-clay layer which had been developed beneath the laterite and bauxite crust of the old peneplain. Enormous tonnages of bauxite must have been stripped off and dissipated during the early phases of the erosive epoch which followed the faulting.

Fossil plants are very abundant in all these Tertiary rocks and some beautifully preserved specimens have been collected. These belong to the widespread Tertiary flora which is characteristic of the Tertiary lake sediments wherever they have been found in Australia. This flora is made up of genera which to-day are characteristic of warmer and more humid climates. Included in the flora are such trees as cinnamons, maples, beeches, planes, elms, pines, banksias, oaks, and willows. Typical leaves collected from these sediments in the Launceston district are shown on Plates IV and V. Within the present area fossils of this type have been found and described from many localities, among which may be mentioned the cuttings on the West Tamar Road adjacent to the golf links, Stevenson's Bend, Muddy Creek and Windmill Hill.

Horizons of laterite and ferruginous sandstone recur at intervals in this Tertiary sequence, particularly in the later phases. Some of the best fossil leaf collecting grounds occur in these highly ferruginous bands. This is not because the leaves are any more abundant there, but only because the iron-rich material is harder and can be handled and stored without falling to pieces. Like the lignite horizons these ferruginous zones probably represent definite phases in the Miocene climatic cycles, and with careful study could probably be used as marker horizons.

Pliocene Basalts

Sedimentation in Lake Launceston was terminated probably during the Pliocene time by the pouring out of floods of basalt. These lava effusions did not cover the whole countryside. The evidence rather indicates that the molten basalt was extruded from many scattered foci in different parts of the island. These separate flows did not join up into a single flood. For example, remnants of a single extrusion of basalt near Launceston extend through the Longford, Perth, Evandale, Breadalbane and St. Leonards districts; there is another large area about Campbell Town and Ross and yet another about Patersonia, but these flows were never connected.

The actual points of eruption have not been located. The lava seems to have been extruded through fissures rather than volcanic vents. Johnston (1888, p. 271) considered that the Cocked Hat Hill, an eminence about a mile from the junction of the Evandale Road and the Midlands Highway at Breadalbane 'may have formed the principal vent for the erupted matter' in the Launceston district. This is a misconception because the Cocked Hat Hill is composed of Jurassic dolerite, not Pliocene basalt. However, it is evident from Johnston's earlier paper (1874, p. 57) that he regarded most of the Jurassic dolerite in the Launceston district as an "older basalt" which baked and metamorphosed the lower members of the Miocene lake sediments at Corra Lynn, St. Leonards and Perth. But these baked and silicified mudstones, which Johnston considered to be metamorphosed Tertiary lake sediments, are in fact Permian (see for comparison Johnston's table, 1874, p. 60).

The basalt, of course, flowed down into the valley on top of the Miocene sediments which had filled the Launceston Lake. A study of the base of the basalt helps us to reconstruct the relief of the landscape of that period. From this it is clear that the Pliocene mountains and ridges were in the same positions and at the same general elevations as they are to-day, but had not been so extensively dissected. The basalt rests on the Miocene beds and thins out against the dip slopes and scarps of the old tilted and step-faulted Oligocene peneplain, which at the time of the eruptions still stuck up through the rising tide of sediments. There had as yet been no erosion of the Miocene sediments in this area, although the pendulum was just about to swing from fill to scour.

The question arises as to whether any uplift movements of the fault blocks occurred at the time of these basalt eruptions which were so widespread throughout Tasmania. The fact that the flows seem to have been for the most part extruded from fissures indicates that the fissures were open and in a state of tension at that time, so there is at least a suggestion that fault block movements may have been in progress. This may well have been so, but so far I have been unable to identify any uplifts directly referable to this epoch. There can be no longer any doubt that the principal uplifts in Tasmania occurred in the Lower Miocene, that these movements initiated the Tertiary lake systems and that the relief in the neighbourhood of the lakes was much the same as to-day. Also there is no evidence that the basalts have been uplifted or tilted since their extrusion. The surface altitudes of the basalt sheets give reasonable figures for the hydraulic gradients of the lava from place to place. The base of the basalt declines from about 800 feet at Campbell Town to about 600 feet at Launceston, and to a little below the present sea level on the lower Tamar (Middle Island). This fall in altitude is merely the thalweg of the Pliocene drainage. There is no evidence of a more recent uplift of any consequence. The fact that the Pliocene thalweg drops below the present sea level at the mouth of the estuary merely means that the sea level during that part of the Pliocene was lower than to-day. Immediately following the lower Miocene faulting active youthful streams cut quickly into the newly-raised scarps fronting the sea. These youthful valleys near the sea received the basalt at levels below the present drowned sea level. The same relationship obtained on the Derwent.

The extrusion of these masses of lava on to the floors of the valleys had of course a pronounced effect on the course of the rivers. Thus, before the eruptions, the South Esk River flowed in a straight valley from near Campbell Town through Evandale and St. Leonards to the Tamar, while the Macquarie River flowed parallel to it on the other side of Hummocky horst. However, the pouring out of the basalt about Evandale dammed the South Esk and diverted it into the Macquarie near Longford, so that it joined forces with the waters sawing their way through the dolerite hills to Trevallyn. This damming of the South Esk caused the accumulation in the Longford district of extensive deposits of post-basalt gravels, referred to by Johnston (1873, pp. 39-44; 1888, p. 253). These gravels are over 100 feet thick near Longford and extend to about 630 feet above sea level. A conspicuous feature of such post-basalt gravels is the abundance of waterworn pebbles of opalised wood, agate, cornelian and various silicified rocks. All this opal and chalcedony and silica is derived from the volcanic liquors which accompanied the basalt lavas.

Post-Pliocene erosion has carved into the basalt barrier between Evandale and St. Leonards, for although the basalt is a relatively hard rock it rests on poor foundations of clay which have been unable to withstand the sapping attack of the North Esk and its little tributary with an oversize valley—Rose Rivulet. As a result of this attack only residuals of the former basalt sheet are found in the St. Leonards district. 7EX Hill and the flat-topped hills at the same elevation immediately to the south-east of 7EX Hill are the only remnants of the basalt sheet still preserved in the area covered by the geological map. But further back about Breadalbane where the basalt is only now starting to be undermined, an extensive sheet remains.

Plio-Pleistocene Erosion

Throughout the whole of this time that the Miocene sediments and Pliocene basalts and post-Basaltic gravels were filling up the Launceston Lake, streams nearer the sea were attacking the barrier separating the lake from the sea. Thus the streams flowing direct into the sea rapidly deepened their valleys by headward erosion towards the Launceston Lake. By the time the basalts were being poured out early in the Pliocene these valleys had already been deepened to below our present sea level, for the basalt is found extending below the waters of the Tamar on Middle Island. This attack continued, and before the end of the Pliocene the main barrier was breached and erosion proceeded at a rapid rate to tear away the earlier deposited sediments which had filled up the lake. Throughout the rest of the Pliocene and Pleistocene this scour and removal went on and the greater part of the filling of the present Tamar Valley was removed, leaving only the more resistant dolerite hills with patches of the Tertiary flanking them in the more sheltored areas.

Something like thirty thousand million tons of Tertiary sediments have been scoured out of the Tamar Valley in the area covered by the geological map, and there is every reason to believe that this erosive process is still going on with undiminished vigour. However, the erosive cycle which began late in the Pliocene may have been going on for from two to five million years, so that the average annual rate of removal is only of the order of from five to ten thousand tons.

Round about Launceston itself the North Esk and the South Esk used to meet on the surface of the old lake bed about 500 feet above the present level of their junction. When the head of erosion reached this point a great difference confronted the two streams. The bed of the North Esk lay entirely in the soft Tertiary rocks as far as Corra Lynn, where the river flowed down from the basalt and dolerite hills on to the surface of the old lake.

Meanwhile, the South Esk flowing over hard dolerite deepened its valley as the level of the Tamar fell, but was unable to wear away the resistant dolerite to any great width. As a consequence the course of this river became entrenched in the dolerite plateau and carved out the narrow gorge which has proved such a beautiful tourist attraction to Launceston. Rose Rivulet, a small tributary of the North Esk which carries on the direction of the North Esk where the latter turns into the hills, is flowing over the same soft Tertiary rocks which had proved so easily cut away in the Tamar Valley. Because of the softness of its bed this small stream with its very limited erosive power has carved out a broad valley extending back towards the South Esk about Evandale. A time will come, unless man intervenes to prevent it, when Rose Rivulet continuing to bite back into its soft watershed will behead the South Esk in the vicinity of Evandale and bring all those waters by this route to the Tamar, leaving only the Meander and Macquarie Rivers to fight their way through the dolerite gorge. The Hummocky horst will eventually stand up as a scarp along the upper South Esk, continuing that which flanks the Tamar between Launceston and Beaconsfield; while the Meander and Macquarie will continue to wander across the plains waiting for headward erosion to wear down the barrier in their course formed by the dolerite gorge through the horst. Finally when the gorge is sawn down to the level of the Tamar throughout its length, the soft Tertiary sediments which fill the Longford-Cressy Basin will be quickly scoured out, the Longford fault scarp will reappear and the present sites of Longford and Perth will be perched on top of a table-topped range looking down on the flat floor of the lowlands of Cressy several hundred feet below.

These events are but glimpses of a distant future and do not concern our present generation. However, Nye (1932) has shown that the diversion of the South Esk waters direct from Evandale to Launceston is imminent quite apart from the headward erosion of Rose Rivulet. For in the great flood of April, 1929, the highest level of the flood waters was only a few feet below the lowest point of the divide between the South Esk and Rose Rivulet. A slightly higher flood would have resulted in the South Esk waters spilling over the divide into Rose Rivulet. Once this happened the scour would be extremely rapid, and a matter of hours would see the South Esk permanently diverted to the direct route from Evandale to Launceston. Such an event could happen in our lifetime.

Meanwhile a considerable proportion of the water which flows down the upper South Esk at Cleveland already takes the short cut to the Tamar by soaking into the pores in the Tertiary sediments and infiltrating its way through permeable rocks below the divide.

Eustatic Changes of Sea Level

During the Plio-Pleistocene cycle of erosion, the normal perturbations of the earth's orbit which result in cyclic changes of climate were reflected in changing rainfall and also in a changing level of the sea. As a result of both these factors the erosion base of the stream was affected and a series of terraces are a prominent feature of the valley about St. Leonards. However, the description of these terraces should not be undertaken without critical analysis and investigation because they have arisen from a variety of causes. For example, the old surface of the basalt is well preserved as a terrace. Likewise certain more resistant horizons within the Tertiary sediments have revealed themselves as terraces merely due to differential erosion. Terraces originating in these two ways must be differentiated from terraces reflecting eustatic changes of sea level. A careful and thorough investigation of these terraces is warranted and would probably shed a good deal of light on the successive changes in sea level over the last half-million years. However, some preliminary observations may be recorded here. One big event which is obvious to all is the drowning of the Tamar Valley. This occurred some ten thousand years ago when the sea level was raised about 270 feet and the sea backed up the Tamar Valley to what had been the 270-feet contour. As a result of this drowning the tides reached St. Leonards, which before had been over 30 miles above tide water. In this way the magnificent drowned estuary of the modern Tamar came into being. A still earlier event is represented by a prominent terrace about 100 feet above the North Esk River in the St. Leonards district. This probably represents a still higher advance of the sea which occurred between three and four thousand years ago. The most recent event of this type was a retreat of the sea by about 15 to 20 feet. This left high and dry a lot of tidal flats along the Tamar which had formed after the 270-foot rise in sea level. Of this type are the waterlogged, swampy areas on both sides of the North Esk about St. Leonards. The North Esk, which is a vigorous stream until it reaches these flats, there becomes bogged down and meanders with all the symptoms of old age until it reaches the Tamar.

This last retreat of the sea made all the difference to the upper Tamar as a deep-water port. Before it happened big ships would have had no difficulty in reaching the city of Launceston at all tides. However, the happy position would have been but short-lived because the tributaries of the Tamar bring down annually large quantities of silt, which accumulates wherever the scour of the river is insufficient to move it on.

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Locality Index

Name	Quadrangle	Latitude S.	Longitude E.
Arthur Mt.	Launceston 39.	41° 17′	147° 18′
Asbestos Point	Macquarie Hbr. 64.	42° 22′	145° 26′
Barrow Mt. (4644′)	Launceston 39.	41° 21′	147° 25′
Beaconsfield	Beaconsfield 30.	41° 11′	146° 45′
Bellerive	Hobart 82.	42° 52′	147° 24′
Ben Lomond Mt. (5010′)	Ben Lomond 48.	41° 37′	147° 41′
Breadalbane	Longford 47.	41° 32′	147° 12′
Bridgenorth	Frankford 38.	41° 23′	146° 59′
Campbell Town	Lake River 54.	41° 54′	147° 30′
Carr Villa	Launceston 39.	41° 28′	147° 10′
Cocked Hat Hill	Longford 47	41° 31′	147° 11′
Corra Lynn	Launceston 39.	41° 29′	147° 14′
Cygnet	Kingborough 88.	43° 10′	147° 7′
Derwent River	Hobart 82.	42° 30′	146° 30′
Dilston	Launceston 39.	41° 20′	147° 5′
Elizabeth River	Snow Hill 55.	41° 54′	147° 34′
Evandale	Longford 47.	41° 34′	147° 15′
Fern Tree	Hobart 82.	42° 55′	147° 15′
Frankford	Frankford 38.	41° 19′	146° 45′
Freshwater Point	Launceston 39.	41° 21′	147° 4′
Glen Dhu	Launceston 39	41° 27′	147° 8′
Hadspen	Longford 47.	41° 31′	147° 4′
Hobart	Hobart 82.	42° 52′	147° 20′
Hummocky Hills	Longford 47.	41° 44′	147° 14′
Launceston	Launceston 39.	41° 26′	147° 5′
Legana	Launceston 39.	41° 22′	147° 3′
Lindisfarne	Hobart 82.	42° 51′	147° 22′
Longford	Longford 47.	41° 35′	147° 6′
Macquarie River	Lake River 54	41° 48′	147° 15′
Meander River	Quamby 46.	41° 31′	146° 40′
Middle Island	Beaconsfield 30.	41° 8′	146° 50′
Mowbray Siding	Launceston 39.	41° 24′	147° 9′
Muddy Creek	Launceston 39.	41° 22′	147° 1′
North Esk River	Launceston 39	41° 30′	147° 13′
Norwich	Longford 47	41° 36′	147° 6′
Ouse	Ouse 67.	42° 29′	146° 43′
Patersonia	Launceston 39.	41° 21′	147° 18′
Perth	Longford 47.	41° 34′	147° 10′
Relbia	Longford 47.	41° 30′	147° 12′
Risdon	Hobart 82.	42° 50′	147° 22′
Rose Rivulet	Longford 47.	41° 32′	147° 16′
Rosevale	Frankford 38.	41° 26′	146° 56′
Ross	Interlaken 61	42° 1′	147° 30′
St. Leonards	Launceston 39.	41° 28′	147° 11′
7EX Hill	Launceston 39.	41° 27′	147° 13′
South Esk River	Alberton 40.	41° 30′	147° 51′
Stevenson's Bend	Launceston 39.	41° 30′	147° 7′
Tamar River	Launceston 39.	41° 16′	147° 7′
Trevallyn	Launceston 39.	41° 26′	147° 7′
Tullochgorum Siding	Ben Lomond 48.	41° 41′	147° 55′
Waddamana P.S.	Lake Echo 60.	42° 7′	146° 45′
Western Junction	Longford 47.	41° 33′	147° 13′
Western Tiers	Lake River 54.	41° 38′	146°
Windmill Hill	Launceston 39.	41° 28	147° 9′
Woodbury	Interlaken 61.	42° 11′	147° 23′

PLATES

PLATE III.—Geological Map of the Launceston District.

PLATE IV.—Miocene fossil leaves from the Launceston series. A. Beech; B. Plane. Natural size. (H.J. Read photo; specimens in coll. Queen Victoria Museum).

PLATE V.—Miocene fossil leaves from the Launceston series. Cinnamon (large leaf) and beech. Natural size. (H. J. Read photo.; specimens in coll. Queen Victoria Museum).

PLATE VI.—Panorama over Tamar Valley and part of the city of Launceston, looking north-east to Mt. Arthur (on skyline). Foreground: First Basin and Cataract Gorge of the South Esk River with Trevallyn Bridge middle distance. Centre and right: North Esk River. Middle distance left: Tamar River. Foreground: dolerite hills of south-west side of Tamar trough. Background: dolerite dip-slopes of north-east side of Tamar trough. (Brown and Dureau air photo. by courtesy of the Tas. Govt. Tourist Bureau.)